STV

MEMORANDUM

DATE: August 13, 2010

TO: Jamie Kendrick

FROM: Brian Biddle, Nick Driban

SUBJECT: Westport Waterfront Transit Oriented Development TIGER II

This memorandum provides a quantitative assessment of the benefits of proposed federal TIGER II grant funds to support transportation in Baltimore's Westport Waterfront Transit Oriented Development. Specifically, STV Incorporated's transportation experts were asked to provide a monetary quantification of the benefits of the development to State of Good Repair and Safety based on the guidelines set forth by the Department of Transportation. It is important to note that improvement costs are quantified elsewhere, this document focuses only on the quantification of benefits from the improvements. This memorandum outlines the methodologies used and the results of the analysis, showing that the project provides extensive benefits to both State of Good Repair and Safety.

State of Good Repair

MD 295 is a major regional parkway connecting Baltimore to I-95, Anne Arundel County and Washington, DC. The parkway averages 80,000 cars per day and was constructed in the 1950's. Two major interchanges serve the Westport Waterfront TOD. The bridge elements supporting these interchanges are severely deteriorated, structurally deficient and functionally obsolete, with Bridge Sufficiency Ratings (BSR) as low as 42.9. The bridges currently suffer from serious issues including deteriorated areas of concrete, heavy rusting, severe map cracking, and failing paint systems. The bridges are approaching the end of their service life and currently require the investment of significant funds to restore adequate long-term structural integrity. TIGER II funds will be used to replace the bridges and reconstruct the ramp geometry to meet today's safety standards and strategically increase roadway capacity.

The primary quantifiable benefit to State of Good Repair results from the savings in maintenance costs that would be realized by making a onetime large investment to replace the bridges, rather than spending a greater amount of funds every few years to perform significant maintenance and repairs to the structures. Quantification of these benefits is based on a lifecycle cost analysis of the cash outlays that would be required to maintain the bridges at their current level including performing significant concrete repairs, steel repairs, cleaning and painting, deck overlay/replacement, and traffic safety upgrades. Grant funds would be used to replace three bridges: Waterview Avenue over MD 295 (BC-5402), Annapolis Road over Waterview Avenue (BC-5407), and Maisel Street Pedestrian Bridge over MD 295 (BC-5001). Information from the Baltimore City Department of Transportation regarding their recurring cash outlays for maintenance of the three affected bridges was acquired. The total cost of maintenance was estimated to be about $1.35 million occurring every four to five years. The proposed use of TIGER funds to reconstruct / replace the structures would "restart" the clock on their respective service lives, providing functioning bridges for 70 to 100 years into the future. For purposes of this analysis, it was assumed that maintaining the existing bridges would require a $1.35 million investment every four years, while maintaining new replacement bridges would require a $1 million investment every ten years. A 40 year analysis period was assumed, which is conservative, given the expected service life of 70 to 100 years for new bridges. A more detailed breakdown of the specific bridge issues and maintenance costs can be found in Appendix A.

The total monetary benefit to State of Good Repair, based on the assumptions outlined above, is $3,401,887.

Safety

Safety benefits were quantified based on the expected reduction in the number of vehicular crashes as a result of the development and associated improvements. The vehicular crash reduction is two-fold: first, a reduction in the existing crashes will be realized due to specific improvements constructed within the local roadway network and, second, benefits will be realized as a result of the mixed-use, transit oriented, urban nature of the proposed development which will result in a lower amount of total vehicular miles traveled generated by the development, compared to what would be expected in a typical suburban stand alone development of the same size (regional norms).

The reduction in the existing number of vehicular crashes is a function of proposed improvements at several intersections around the development, a list of which can be found in Appendix B. Benefits based on these improvements were quantified using the *Desktop Reference for Crash Reduction Factors; Report No. FHWA-SA-08-011* which provides specific crash reduction factors based on the type of improvement. The expected number of reduced crashes per year was calculated and a total annual benefit was determined based on the average cost per crash at each intersection. Supporting tables for all calculations can be found in Appendix B. The final overall reduction in crashes and the resultant benefit over a 20-year period was calculated based on the Department of Transportation's guidance on the value of life and injuries. The table below shows that approximately 5.83 existing crashes would be eliminated annually, or about 117 crashes over a 20 year span, resulting in savings of $2,585,882 over 20 years, discounted to present value.

Summary of Crash Reduction Benefits due to Intersection Improvements

Off-Site Improvements	Annual Number of Crashes Eliminated	Initial Crash Savings	Savings over 20 years (NPV)
Annapolis Road at Manokin Street	0.49	$20,167	$228,605
Annapolis Road at Monroe Street	0.61	$54,448	$617,200
Annapolis Road at Clare Street	0.42	$20,797	$235,746
Annapolis Road at Wenburn Street	0.74	$6,087	$68,943
BW Parkway/ Russell Street (0.87 mi roadway segment)	3.57	$126,608	$1,435,177
TOTAL	**5.83**	**$228,103**	**$2,585,882**

The total number of crashes reduced as a result of the mixed-use, transit oriented, urban nature of the proposed development and the resultant reduction expected in the number of total vehicular miles traveled, compared to what would be expected in a typical suburban stand alone development of the same size (the regional norm) should also be considered as a benefit. Experts on the effects of this type of development have determined that the Westport Development would likely lead to a reduction of 14,942,216 annual vehicle miles traveled compared to regional norms. (*Westport Environmental and Energy Benefits Memorandum*) Assuming the statewide average rates for fatality crashes (1.1 per 100 million vehicle miles traveled) and injury crashes (93.3 per 100 million vehicle miles traveled) an expected annual reduction in crashes due to the nature of the development can be calculated as follows: (*Maryland Traffic Safety Facts 2008, Table 3)*

14,942,216 annual vehicle miles traveled * 1.1 fatalities per 100,000,000 vehicles miles traveled = 0.16 annual fatal crashes reduced

14,942,216 annual vehicle miles traveled * 93.3 injuries per 100,000,000 vehicles miles traveled = 13.7 annual injury crashes reduced

Based on the Department of Transportation's guidance on the value of life and injuries and assuming a seven percent discount rate, the total monetary benefit due to the mixed-use, transit oriented urban nature of the development would be $24,480,902. The total number of crashes reduced over a twenty year period would be 3.2 fatality crashes, and 274 injury accidents. Appendix B contains the supporting tables and documentation.

The total monetary benefit due to the two types of crash reductions, existing and because of the nature of the development, is $27,066,784, with a reduction of about 394 crashes expected over the 20 year analysis period.

APPENDIX

A

Supplemental State of Good Repair Information

State of Good Repair Benefits due to Reduced Maintenance Costs

Road	Net Present Value[1]	1	5	9	10	13	17	20	21	25	29	30	33	37	40
Maintenance with no Replacement	$4,222,329	$1,350,000	$1,029,909	$785,712	$0	$599,416	$457,292	$0	$348,866	$266,148	$203,043	$0	$154,901	$118,173	$0
Maintenance after Replacement	$820,442	$0	$0	$0	$543,934	$0	$0	$276,508	$0	$0	$0	$140,563	$0	$0	$71,455
Total[2]	**$3,401,887**	**$1,350,000**	**$1,029,909**	**$785,712**	**-$543,934**	**$599,416**	**$457,292**	**-$276,508**	**$348,866**	**$266,148**	**$203,043**	**-$140,563**	**$154,901**	**$118,173**	**-$71,455**

1- Assumes 7% Discount Rate, 40 year Analysis Period

2-Total Benefit equals maintenance cost with no replacement ($3.65 million every 4 years) minus maintenance cost after replacement ($3 million every 10 years)

FROM	NAME & TITLE	Scott B. Weaver, P.E., Bridge Project Engineer	CITY of BALTIMORE MEMO
	AGENCY NAME & ADDRESS	Transportation Engineering & Construction Division 417 East Fayette Street, Room 716	
	SUBJECT	Bridges located within the Westport Development Area	

TO

Barbara Zektick, Legislative Officer
Baltimore City Department of Transportation
417 E. Fayette Street, Room 350

August 13, 2010

Below is the list of bridges located within the Westport Development Area and a summary of their current conditions that you requested.

BC 5001 – Maisel Street Pedestrian Bridge over 295
BC 5102 – Russell Street Viaduct over Monroe Street
BC 5103 – Russell Street over CSX
BC 5104 – Russell Street over Gwynns Falls & CSX
BC 5221 – Monroe Street Ramp over CSX
BC 5401 – Annapolis Road over BW Parkway
BC 5402 – Waterview Avenue over BW Parkway
BC 5403 – Waterview Ramp over BW Parkway Ramp
BC 5407 – Annapolis Road over Waterview Avenue

BC 5001 – Maisel Street Pedestrian Bridge over 295

Bridge No. BC 5001 is a two (2) span (79’-6”, 78’-6”) simply supported steel beam pedestrian bridge built in 1950. The bridge has an overall length of 158’-0” with a curb-to-curb width of 7’-0”. The superstructure consists of two simply supported, painted steel beams supporting a cast-in-place reinforced concrete deck. The substructure consists of reinforced concrete abutments, stone wing walls and one reinforced concrete pier. There are chain link safety fences along the approaches and reinforced concrete curbs with a fully enclosed chain link safety fence on the bridge parapets.

Overall, the bridge is in fair condition. Since the bridge carried only pedestrian traffic no Bridge Sufficiency Rating (BSR) is calculated for the structure by the Maryland State Highway Administration. The steel beams are heavily corroded and the paint system has failed. There are also areas of moderate to heavy corrosion at the beam supports (bearings).

Unfortunately, this bridge is of concern due to the way it was built. There is no system of “redundancy” with this bridge. What this means is that if anything happens to one of the 2 steel beams supporting the bridge, then the bridge could potentially collapse. While the bridge has not deteriorated to the point of being in any danger this is still an important fact of note.

BC 5102 – Russell Street Viaduct over Monroe Street

Bridge BC 5102 is a eleven span multi-beam bridge built in 1963 and reconstructed in 2005. The bridge has an overall length of 1049'-0" with a curb-to-curb width of 96'-5" and carries five lanes, two eastbound and three westbound. The superstructure in Spans 1 - 5 consist of steel beams and Spans 6 - 11 consist of concrete beams supporting a reinforced concrete deck. The substructure consists of reinforced concrete abutments, wing walls, and piers.

The bridge is not currently posted for a weight restriction.
Overall, the bridge was in very good condition with a Bridge Sufficiency Rating(BSR) of 92.0.

There are no real problems of note

BC 5103 – Russell Street over CSX

Bridge No. BC 5103 is a three span steel multi-beam bridge built in 1963. The bridge has an overall length of 212'-0" with a curb-to-curb width of 110'-6" and carries seven lanes, four in the north direction and three in the south direction. The superstructure consists of sixteen beams supporting a bituminous coated concrete deck. The substructure consists of reinforced concrete abutments, wing walls and two reinforced concrete piers. There are W-Beam traffic barriers along the approaches and a one-strand aluminum railing on top of a concrete parapet on the bridge.

The bridge is not currently posted for a weight restriction.
Overall, the bridge was in fair condition with a Bridge Sufficiency Rating(BSR) of 69.2.

The paint is peeling off of the beams primarily at the top of all beams. Beams 1 thru 6 has moderate paint failure throughout and Beams 9 and 10 has moderate paint failure on the east web face. The bottom of Beam 5 has paint failure with moderate corrosion up to 10'+/- from Pier 2 in Span 2. The bottom flange of Beam 6 has paint failure with moderate corrosion along 25% of the bottom flange. The ends of all beams up to 6’-0” near the bearing areas of the piers and abutments contain typical light to moderate surface rust with localized areas of heavy rust with section loss up to 25%.

Water leaking from the bridge joints has caused severe erosion of the slope protection and undermined the footings at both abutments. There is deteriorated concrete at numerous locations throughout the substructure.

BC 5104 – Russell Street over Gwynns Falls & CSX

Bridge No. BC 5104 is a four span continuous multi-steel girder bridge built in 1963 and reconstructed in 1990. The bridge has an overall length of 482’-0” with a curb-to-curb width of 120’-0” and carries 8 lanes, 4 in each direction (north and south). The superstructure consists of eleven continuously supported, painted, steel girders supporting a cast-in-place reinforced concrete deck. The substructure consists of reinforced concrete abutments, wing walls and three concrete piers. There are W-Beam traffic barriers along the approaches and reinforced concrete Jersey parapets on the bridge.

The bridge is not currently posted for a weight restriction.
Overall, the bridge was in fair condition with a Bridge Sufficiency Rating(BSR) of 73.6.

The paint is failing on the girders at several locations. The exposed steel has light corrosion.
The vertical section of the end diaphragm at the South Abutment in Bays 1 and 9 have buckled. The gap between the angles is filled with grout.

There are numerous areas of deteriorated concrete at the corners of the bearing supports at the North Abutment. There are several areas of deteriorated concrete throughout the Abutments and Piers. There was water leakage through the south abutment deck joint, most pronounced in Bays 1, 3, 5, and 6. The southwest wing wall is undermined.

BC 5221 – Monroe Street Ramp over CSX

Bridge No. BC 5221 is a three span steel multi-beam bridge built in 1963. The bridge has an overall length of 207’-0” with a curb-to-curb width of 26’-0” and carries two lanes, both in one direction (south). The superstructure consists of four steel beams supporting a concrete deck. The substructure consists of reinforced concrete abutments , wing walls and two reinforced concrete piers. There are W-Beam traffic barriers along the approaches and reinforced concrete parapet traffic barriers with a W-Beam traffic barrier on top of the parapets on the bridge.

The bridge is not currently posted for a weight restriction.
Overall, the bridge was in poor condition with a Bridge Sufficiency Rating(BSR) of 53.0.

There are numerous deteriorated areas of concrete in the bottom face of the bridge deck and along the top face of the west traffic barrier
The water leaking from the roadway joints has caused heavy rusting on all elements under these joints. The anchor bolts typically exhibit moderate to heavy rusting with up to 30% section loss. The unprotected slopes on both sides is heavily eroded exposing the abutment footings in some areas. The drainage flumes at the east and west sides of the North Abutment are undermined. There are numerous areas of deteriorated concrete throughout the substructure.

BC 5401 – Annapolis Road over BW Parkway

Bridge No. BC 5401 is a four span steel multi-beam bridge built in 1919 and rehabilitated in 1949. The bridge has an overall length of 305’-0” +/- and with a curb-to-curb width of 36’-0” +/- and carries two lanes, one in each direction. The superstructure consists of seven steel beams supporting the concrete deck. The substructure consists of reinforced concrete abutments and piers. There are W-beam traffic barriers along the approaches and on the bridge.

The bridge is currently posted for 48,000 lbs for Single Unit Vehicles and 54,000 lbs for Combination Vehicles.
Overall, the bridge was in poor condition with a Bridge Sufficiency Rating(BSR) of 35.2.

The light pilasters are in poor condition and typically exhibit severe map cracking up to 1/8" wide and deterioration along the base.
There is deteriorated concrete along the curbs. Sections of the steel joint angle at roadway Joint 1 have been removed due to severe rusting.
The paint system has failed on all elements of the superstructure exposing heavy rust, pack rust, and severe section loss on most steel bridge elements.

There is a new temporary support system installed since the 2005 inspection at Pier 1. The new support is a combination of two steel frame structures with separate bearings to support the beams. The original pier is still in place but not supporting any load. The pier continues to deteriorate. The bearing plates at Beam 4 are misaligned horizontally by up to 5” causing loss of bearing. There is deteriorated concrete throughout the substructure and widespread cracking.

BC 5402 – Waterview Avenue over BW Parkway

This bridge is a two span steel multi-beam bridge built in 1950. The bridge has an overall length of 129'-0" with a curb-to-curb width of 56'-0" and a 4'-0" wide median, and carries two lanes in each direction. The superstructure consists of 12 steel beams supporting a concrete deck. The substructure consists of reinforced concrete abutments, one pier and wing walls. The West Abutment of this bridge is integral with the north end of the tunnel structure at Annapolis Road (Bridge BC 5407). There is a concrete parapet with a single strand steel railing along the approaches and on the bridge.

There is a posting sign at the west end of the bridge on the northbound lane of Annapolis Road. The sign appears to be misplaced since it does not match the inventory ratings for this bridge.
Overall, the bridge was in fair condition with a Bridge Sufficiency Rating(BSR) of 63.6.

There are areas of deteriorated concrete in the sidewalks, median, and traffic barrier. The paint system has failed at all beams exposing light rust in the middle of the span and moderate to heavy rust at the bearings. The vertical stiffeners at the bearings on the pier are heavily rusted with several rust holes. The heavy rusting of beam 1 has caused the beam to warp, slightly. There several anchor bolts that are severely corroded.

There are numerous areas of deteriorated concrete throughout the substructure. There is 1" of ponded water in the access chamber with active water flow down the abutment at the north end of the West Abutment. There is a utility pipe inside a square concrete encasement in Bay 3 that has patches covering the joints. The patches near the east abutment are failing and are located above the travel lanes with the potential to detach and fall onto the roadway below. A Letter of concern, dated 2/6/08, was received by the DOT in regards to the hazard posed to motorists under the bridge. Due to the widespread areas of deteriorated concrete in the substructure, the possibility does exist that pieces of deteriorated concrete could fall off of the bridge and strike motorists.

BC 5403 – Waterview Ramp over BW Parkway Ramp

Bridge No. BC 5403 is a single, 66'-0" span, Concrete T-beam bridge built in 1950. The bridge has an overall length of 75'-0" with a curb-to-curb width of 56'-0" and a 4'-0" wide median, and carries four lanes, two in each direction. The superstructure consists of fourteen simply supported reinforced concrete beams supporting a reinforced concrete deck. The substructure consists of reinforced concrete abutments and wing walls. There are W-Beam traffic barriers along the east side of the approaches and reinforced concrete parapets with a single strand steel railing on the bridge.

The bridge is not currently posted and no advance warning signs were located for this bridge, however the bridge was recommended for posting during the 2005 inspection cycle.
Overall, the bridge was in fair condition with a Bridge Sufficiency Rating(BSR) of 75.9.

There are several areas of deteriorated concrete throughout the superstructure. There are also areas of deteriorated concrete in the substructure.

BC 5407 – Annapolis Road over Waterview Avenue

Bridge No. BC 5407 is a 625’-0” long abandoned tunnel supporting two lanes of Annapolis Road. The original tunnel structure consists of a rigid frame with concrete walls and top slab and was built in 1920. In 1945 a load relieving platform was constructed on the west side of the tunnel adjacent to two sections of its length. One relieving platform section is 265’ long beginning at the south end. The second tunnel section with a load relieving platform starts 365’ from the south end and ends 460’ from the south end. The relieving platform section is composed of a concrete top slab and approximately 9 feet of earth fill supported on piles. The tunnel supports the northbound lanes of Annapolis Road and the relieving platform supports the southbound lanes of Annapolis Road. Beginning at the north end, the tunnel consists of a concrete top slab with an average earth fill of 9’ and an encased steel beam system supported on a concrete wall with stone facing on the east side and a counterfort wall on the west side. This section extends 165 feet from the north end. Another section with a concrete top slab and encased steel beam system begins at 265 feet from the south end and ends 365 feet from the south end of tunnel.

There was no posting signs at the bridge or at the approaches at the time of inspection.
Overall, the bridge was in poor condition with a Bridge Sufficiency Rating(BSR) of 42.9.

Tunnel Interior

The same basis of reference from the previous inspection was used for presentation of inspection data of the tunnel’s interior. The tunnel interior was divided into sections. Section 1 is a concrete rigid frame tunnel with a load relieving platform. Section 2 is the tunnel section with the counterfort wall. The top slab of Section 2 of the tunnel is a combination concrete slab and concrete encased steel beam system supported on concrete walls. Elevation views of the west and east walls as well as ceiling plans along with detailed inspection findings are shown graphically in Appendix A.

There are areas of severely deteriorated concrete throughout the tunnel. The steel beams and piles are corroding at numerous locations.

Please let me know if you need any more information or have any additional questions.

Scott B. Weaver
SCOTT B. WEAVER
BRIDGE PRJECT ENGINEER III

Charles N. Driban

From: Weaver, Scott [Scott.Weaver@baltimorecity.gov]
Sent: Friday, August 13, 2010 1:56 PM
To: Charles N. Driban; Zektick, Barbara; Amy Bonitz
Subject: RE: language from app

Not annual. But, cost that would be incurred every few years until the bridges collapse.

From: Charles N. Driban [mailto:Charles.Driban@stvinc.com]
Sent: Fri 8/13/2010 7:30 AM
To: Weaver, Scott; Zektick, Barbara; Amy Bonitz
Subject: RE: language from app

Thanks Scott, would these be considered annual costs of maintenance?

From: Weaver, Scott [mailto:Scott.Weaver@baltimorecity.gov]
Sent: Friday, August 13, 2010 12:16 AM
To: Charles N. Driban; Zektick, Barbara; Amy Bonitz
Subject: RE: language from app

Charles,
According to estimates from the 2007 Bridge Inspection reports

BC-5401	Annapolis Road over MD 295, B/W Parkway	$2,000,000
BC-5402	Waterview Ave over B/W Parkway	$200,000
BC-5403	Waterview Avenue Ramp over MD 295, B/W Parkway	$100,000
BC-5407	Annapolis Road over Waterview Avenue	$900,000
BC-5001	Maisel Street Ped Bridge over MD 295	$250,000
BC-5221	Monroe Street Ramp over CSX	$200,000
	Total	$3,650,000

Please keep in mind that simply repairing these defects <u>will not</u> make them go away. This will band-aid the bridges. Eventually, the bridges will fail and this will have devastating consequences including loss of life.

You have to look at this the same way you look at an old car. You can repair it and keep it on the road, instead of buying a new one. But, eventually, it will get to a point beyond repair and will break down leaving you stranded somewhere and will not be able to be fixed; just replaced.

Scott

From: Charles N. Driban [mailto:Charles.Driban@stvinc.com]
Sent: Thu 8/12/2010 6:38 PM
To: Weaver, Scott; Zektick, Barbara; Amy Bonitz
Subject: RE: language from app

Hi Scott and Barbara,

APPENDIX

B

Supplemental Safety Information

Crash Reduction Benefits Due to Intersection Improvements

Road	Net Present Value[2]	Initial Benefit[1]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Annaplis Road at Monroe Street	$617,200	$54,448	$54,448	$50,886	$47,557	$44,446	$41,538	$38,821	$36,281	$33,907	$31,689	$29,616	$27,679	$25,868	$24,176	$22,594	$21,116	$19,734	$18,443	$17,237	$16,109	$15,055
Annaplis Road at Wenburn Street	$68,943	$6,082	$6,082	$5,684	$5,312	$4,965	$4,640	$4,336	$4,053	$3,788	$3,540	$3,308	$3,092	$2,890	$2,700	$2,524	$2,359	$2,204	$2,060	$1,925	$1,799	$1,682
Annapolis Road at Clare Street	$235,746	$20,797	$20,797	$19,436	$18,165	$16,977	$15,866	$14,828	$13,858	$12,951	$12,104	$11,312	$10,572	$9,881	$9,234	$8,630	$8,065	$7,538	$7,045	$6,584	$6,153	$5,751
Annapolis Rd at Manokin St	$228,605	$20,167	$20,167	$18,848	$17,615	$16,462	$15,385	$14,379	$13,438	$12,559	$11,737	$10,970	$10,252	$9,581	$8,954	$8,369	$7,821	$7,309	$6,831	$6,384	$5,967	$5,576
Russel Street/ BW Parkway	$1,435,177	$126,608	$126,608	$118,325	$110,584	$103,350	$96,589	$90,270	$84,364	$78,845	$73,687	$68,866	$64,361	$60,151	$56,215	$52,538	$49,101	$45,889	$42,887	$40,081	$37,459	$35,008
Total	**$2,585,882**		**$228,103**	**$213,181**	**$199,236**	**$186,203**	**$174,023**	**$162,640**	**$152,001**	**$142,058**	**$132,766**	**$124,082**	**$115,966**	**$108,382**	**$101,293**	**$94,668**	**$88,477**	**$82,691**	**$77,283**	**$72,229**	**$67,506**	**$63,092**

1- See supporting Benefit/ Cost Analysis Worksheets

2- Assumes 7% Discount Rate, 20 year Analysis Period

The off-site transportation infrastructure improvements related to the Westport Waterfront Transit Oriented Development enhances safety of existing facilities. The proposed ramp improvements along Russell Street, intersection improvements along Annapolis Road and Waterview Avenue, pedestrian and bicycle trail improvements connecting the site and the railroad crossing safety improvements adjoining the site provide a safer movement for various modes of travel. Due to the constraints in the availability of crash data, a reduction in crashes associated with specific improvements was not calculated. However, the crash reduction potential of the specific improvements per the Federal Highway Administration's Desktop Reference for Crash Reduction Factors is presented in the table below:

Summary of Improvements and Associated Crash Reduction Factors

Off-Site Improvements	Crash Reduction Factor (%)
Annapolis Rd./Waterview Ave./Russell St. Interchange Improvements (Roadway): – Widen Ramp, Increase acceleration lane length	26
Extend NB MD 295 Deceleration Lane to Waterview Avenue	26
Widen NB MD 295 Ramp to Waterview Avenue	26
Extend SB MD 295 On-Ramp from Annapolis Road	26
SB MD 295/SB I-95 to Annapolis Road (Reduce Lanes)	26
Annapolis Road/Monroe Street: Signal Phasing Modification, Install a Left-Turn Lane	58
Annapolis Road/Clare Street: Install a New Signal	20
Annapolis Road/Manokin Street: Signal Phasing Modification, Install a Right-Turn Lane	28
Manokin Street - One-way conversion	43
Wenburn Street - One-way conversion	43
Annapolis Road/Russell Street Exit Ramp from NB I-95: Widen to provide right-turn lane	26
Waterview Avenue Resurfacing	33
Kent Street Light Rail Pedestrian Bridge	86

Source: Desktop Reference for Crash Reduction Factors; Report No. FHWA-SA-08-011, Sep '08

Based on the crash reduction factors cited in the table above, 26-86% reduction in crashes can be expected from the proposed off-site transportation infrastructure improvements.

Off-Site Improvements	CRF Page No.
Install acceleration/deceleration lanes	62
Install acceleration/deceleration lanes	62
Increase number of lanes	60
Install acceleration/deceleration lanes	62
Narrow cross section (4 to 3 lanes)	63
Provide E/P Let-Turn Phasing, Install a left-turn lane	8,19
Install Signals	15
Provide Split Phasing, Install a right-turn lane	12-26
Convert two-way roadway to one-way	40
Convert two-way roadway to one-way	40
Install a right-turn lane	26
Resurface Pavement	38
Install Raised Pedestrian Crossing	100

Baltimore City Department of Transportation — *Date:* 9/27/2010 — *Name:* CND

Intersection Benefit/Cost Analysis

Location: *Annapolis Rd at Manokin St*

Collision Type		2005	2006	2007	Total	Rate	Proj. Acc.
1	Angle			2	2	0.2	0.7
2	Rear End			0	0	0.0	0.0
3	Fixed Object			0	0	0.0	0.0
4	Head On			0	0	0.0	0.0
5	Sideswipe			0	0	0.0	0.0
6	Left Turn			0	0	0.0	0.0
7	Pedestrian			0	0	0.0	0.0
8	Parked Vehicle			0	0	0.0	0.0
9	Other Collision			3	3	0.3	1.1
10	Wet Surface			0	0	0.0	0.0
11	Night Accidents			0	0	0.0	0.0
	Total (Type 1 through 9)	0	0	5	5		
1/2 Combined ADT		10,300	10,500	10,700	31,500	Proj. ADT =	11,100
Million Vehicles Entering		3,759,500	3,832,500	3,905,500	11,497,500	Proj. MVE =	4,051,500

The 2007 Crash Column Contains Three Years of Data

Collision Type		Projected Accident Experience	Accident Reduction Factor %	Average Accident Cost	Forecasted Reduction (# Accidents)	First Year Benefit
1	Angle	0.7	28	$ 40,880	0.20	$ 8,067
9	Other Collision	1.1	28	$ 40,880	0.30	$ 12,100
		0.0			0.00	$ -
				Total	0.49	$ 20,167

Average Cost per Accident based on Crash Data

Average Accident Cost		**No of Crashes at Int**	
Fatal	$5,800,000	0	
Injury	$89,900	2	Conservatively assumes typical injury crash is moderate severity (MAIS 2)
PDO	$8,200	3	

Average Accident Cost $40,880

Baltimore City Department of Transportation Date: 9/27/2010
Name: SM

Intersection Benefit/Cost Analysis

Location: Annapolis Road at Clare Street

	Collision Type	2005	2006	2007	Total	Rate	Proj. Acc.
1	Angle			0	0	0.0	0.0
2	Rear End			1	1	0.2	0.4
3	Fixed Object			0	0	0.0	0.0
4	Head On			0	0	0.0	0.0
5	Sideswipe			2	2	0.4	0.7
6	Left Turn			1	1	0.2	0.4
7	Pedestrian			0	0	0.0	0.0
8	Parked Vehicle			0	0	0.0	0.0
9	Other Collision			2	2	0.4	0.7
10	Wet Surface			0	0	0.0	0.0
11	Night Accidents			0	0	0.0	0.0
	Total (Type 1 through 9)	0	0	6	6		
	1/2 Combined ADT	4,900	5,000	5,100	15,000	Proj. ADT =	5,300
	Million Vehicles Entering	1,788,500	1,825,000	1,861,500	5,475,000	Proj. MVE =	1,934,500

The 2007 Crash Column Contains Three Years of Data

	Collision Type	Projected Accident Experience	Accident Reduction Factor %	Average Accident Cost	Forecasted Reduction (# Accidents)	First Year Benefit
2	Rear End	0.4	20	$ 49,050	0.07	$ 3,466
5	Sideswipe	0.7	20	$ 49,050	0.14	$ 6,932
6	Left Turn	0.4	20	$ 49,050	0.07	$ 3,466
9	Other Collision	0.7	20	$ 49,050	0.14	$ 6,932
				Total	0.42	$ 20,797

Average Cost per Accident based on Crash Data

Average Accident Cost		No of Crashes at Int	
Fatal	$5,800,000	0	
Injury	$89,900	3	Conservatively assumes typical injury crash is moderate severity (MAIS 2)
PDO	$8,200	3	

Average Accident Cost $49,050

Baltimore City Department of Transportation Date: 9/27/2010
Name: CND

Intersection Benefit/Cost Analysis

Location: Russel Street/ BW Parkway

	Collision Type	2005	2006	2007	Total	Rate	Proj. Acc.
1	Angle			0	0	0.0	0.0
2	Rear End			23	23	2.0	8.1
3	Fixed Object			11	11	1.0	3.9
4	Head On			0	0	0.0	0.0
5	Sideswipe			5	5	0.4	1.8
6	Left Turn			0	0	0.0	0.0
7	Pedestrian			0	0	0.0	0.0
8	Parked Vehicle			0	0	0.0	0.0
9	Other Collision			0	0	0.0	0.0
10	Wet Surface			0	0	0.0	0.0
11	Night Accidents			0	0	0.0	0.0
	Total (Type 1 through 9)	0	0	39	39		
	1/2 Combined ADT	10,300	10,500	10,700	31,500	Proj. ADT =	11,100
	Million Vehicles Entering	3,759,500	3,832,500	3,905,500	11,497,500	Proj. MVE =	4,051,500

The 2007 Crash Column Contains Three Years of Data

	Collision Type	Projected Accident Experience	Accident Reduction Factor %	Average Accident Cost	Forecasted Reduction (# Accidents)	First Year Benefit
2	Rear End	8.1	26	$ 35,433	2.11	$ 74,666
3	Fixed Object	3.9	26	$ 35,433	1.01	$ 35,710
5	Sideswipe	1.8	26	$ 35,433	0.46	$ 16,232
				Total	3.57	$ 126,608

Average Cost per Accident based on Crash Data

Average Accident Cost		**No of Crashes at Int**	
Fatal	$5,800,000	0	
Injury	$89,900	13	Conservatively assumes typical injury crash is moderate severity (MAIS 2)
PDO	$8,200	26	

Average Accident Cost $35,433

Baltimore City Department of Transportation Date: 9/27/2010
Name: SM

Intersection Benefit/Cost Analysis

Location: *Annapolis Road at Wenburn Street*

	Collision Type	2005	2006	2007	Total	Rate	Proj. Acc.
1	Angle			3	3	0.3	1.0
2	Rear End			0	0	0.0	0.0
3	Fixed Object			0	0	0.0	0.0
4	Head On			0	0	0.0	0.0
5	Sideswipe			0	0	0.0	0.0
6	Left Turn			2	2	0.2	0.7
7	Pedestrian			0	0	0.0	0.0
8	Parked Vehicle			0	0	0.0	0.0
9	Other Collision			0	0	0.0	0.0
10	Wet Surface			0	0	0.0	0.0
11	Night Accidents			0	0	0.0	0.0
	Total (Type 1 through 9)	0	0	5	5		
	1/2 Combined ADT	8,500	8,600	8,700	25,800	Proj. ADT =	8,900
	Million Vehicles Entering	3,102,500	3,139,000	3,175,500	9,417,000	Proj. MVE =	3,248,500

The 2007 Crash Column Contains Three Years of Data

	Collision Type	Projected Accident Experience	Accident Reduction Factor %	Average Accident Cost	Forecasted Reduction (# Accidents)	First Year Benefit
1	Angle	1.0	43	$ 8,200	0.45	$ 3,649
6	Left Turn	0.7	43	$ 8,200	0.30	$ 2,433
	--					$ -
	--					$ -
				Total	0.74	$ 6,082

Average Cost per Accident based on Crash Data

Average Accident Cost		No of Crashes at Int	
Fatal	$5,800,000	0	
Injury	$89,900	0	Conservatively assumes typical injury crash is moderate severity (MAIS 2)
PDO	$8,200	5	

Average Accident Cost $8,200

Baltimore City Department of Transportation

Date: *9/27/2010*
Name: *SM*

Intersection Benefit/Cost Analysis

Location: *Annapolis Road at Monroe Street*

The 2007 Crash Column Contains Three Years of Data

	Collision Type	2005	2006	2007	Total	Rate	Proj. Acc.
1	Angle			0	0	0.0	0.0
2	Rear End			0	0	0.0	0.0
3	Fixed Object			0	0	0.0	0.0
4	Head On			0	0	0.0	0.0
5	Sideswipe			0	0	0.0	0.0
6	Left Turn			3	3	0.4	1.0
7	Pedestrian			0	0	0.0	0.0
8	Parked Vehicle			0	0	0.0	0.0
9	Other Collision			0	0	0.0	0.0
10	Wet Surface			0	0	0.0	0.0
11	Night Accidents			0	0	0.0	0.0
	Total (Type 1 through 9)	0	0	3	3		
	1/2 Combined ADT	6,700	6,750	6,900	20,350	Proj. ADT =	7,083
	Million Vehicles Entering	2,445,500	2,463,750	2,518,500	7,427,750	Proj. MVE =	2,585,417

	Collision Type	Projected Accident Experience	Accident Reduction Factor %	Average Accident Cost	Forecasted Reduction (# Accidents)	First Year Benefit
6	Left Turn	1.0	58	$ 89,900	0.61	$ 54,448
	--	0.0		$ 89,900	0.00	$ -
		0.0			0.00	$ -
				Total	0.61	$ 54,448

Average Cost per Accident based on Crash Data

Average Accident Cost		No of Crashes at Int	
Fatal	$5,800,000	0	
Injury	$89,900	3	Conservatively assumes typical injury crash is moderate severity (MAIS 2)
PDO	$8,200	0	

Average Accident Cost $89,900

Crash Reduction Benefits Due to Reduction in Vehicle Miles Traveled

Road	Net Present Value[2]	Initial Benefit[1]	1	2	3	4	5	6	7	8	9	10
Fatal Crashes	$10,519,432	$928,000	$928,000	$867,290	$810,551	$757,524	$707,967	$661,651	$618,366	$577,912	$540,104	$504,771
Injury Crashes	$13,961,259	$1,231,630	$1,231,630	$1,151,056	$1,075,753	$1,005,377	$939,605	$878,135	$820,687	$766,997	$716,820	$669,925
Total	**$24,480,902**		**$2,159,631**	**$2,018,348**	**$1,886,307**	**$1,762,905**	**$1,647,576**	**$1,539,792**	**$1,439,060**	**$1,344,917**	**$1,256,933**	**$1,174,706**

Road	11	12	13	14	15	16	17	18	19	20
Fatal Crashes	$471,748	$440,886	$412,043	$385,087	$359,894	$336,350	$314,346	$293,781	$274,562	$256,600
Injury Crashes	$626,098	$585,139	$546,858	$511,083	$477,647	$446,399	$417,196	$389,903	$364,395	$340,556
Total	**$1,097,857**	**$1,026,037**	**$958,915**	**$896,184**	**$837,557**	**$782,765**	**$731,558**	**$683,702**	**$638,976**	**$597,176**

1- 0.16 Fatalities Reduced, $5,800,000 per Fatality. 13.7 Injury Accidents Reduced, $89,900 per Injury (Conservatively assumes injuries are moderate severity, MAIS 2)

2- Assumes 7% Discount Rate, 20 year Analysis Period

Maryland Traffic Safety Facts 2008

Maryland Department of Transportation

Charles "McC." Mathias, Jr., National Study Center for Trauma and Emergency Medical Systems

SHA State Highway Administration

Table 3 - Persons Killed or Injured and Fatality and Injury Rates per Population, Licensed Drivers, Registered Vehicles and Vehicle Miles Traveled, 2004-2008

Killed									
Year	**Fatalities**	**Resident Population (Thousands)**	**Fatality Rate per 100,000 Population**	**Licensed Drivers (Thousands)**	**Fatality Rate per 100,000 Licensed Drivers**	**Registered Motor Vehicles (Thousands)**	**Fatality Rate per 100,000 Registered Vehicles**	**Vehicle Miles Traveled***	**Fatality Rate per 100 Million Vehicle Miles Traveled**
2004	643	5,558	11.6	3,820	16.8	4,562	14.1	55.1	1.2
2005	614	5,600	11.0	3,872	15.9	4,498	13.6	56.7	1.1
2006	651	5,615	11.6	3,872	16.8	4,691	13.9	56.6	1.2
2007	615	5,618	10.9	3,966	15.5	4,749	13.0	56.8	1.1
2008	592	5,634	10.5	4,022	14.7	4,756	12.4	56.1	1.1
Injured									
Year	**Injuries**	**Resident Population (Thousands)**	**Injury Rate per 100,000 Population**	**Licensed Drivers (Thousands)**	**Injury Rate per 100,000 Licensed Drivers**	**Registered Motor Vehicles (Thousands)**	**Injury Rate per 100,000 Registered Vehicles**	**Vehicle Miles Traveled***	**Injury Rate per 100 Million Vehicle Miles Traveled**
2004	57,409	5,558	1,032.9	3,820	1,502.8	4,562	1,258.4	55.1	97.6
2005	55,303	5,600	987.6	3,872	1,428.3	4,498	1,229.5	56.7	97.5
2006	53,615	5,615	954.8	3,872	1,384.7	4,691	1,142.9	56.6	94.7
2007	51,729	5,618	920.8	3,966	1,304.3	4,749	1,089.3	56.8	91.1
2008	48,143	5,634	854.5	4,022	1,197.0	4,756	1,012.2	56.1	85.8

*In billions